



# PATENT SPECIFICATION

642,892

Date of Application and filing Complete Specification: Aug. 1, 1946.

No. 23001/46.

Application made in United States of America on March 22, 1945.

Complete Specification Published: Sept. 13, 1950.

Index at acceptance:—Classes 38(ii), T(1f: 8); and 95, B4(b: x).

## COMPLETE SPECIFICATION

### Improved Moisture-Resistant Coating and Method of Producing it

We, WESTERN ELECTRIC COMPANY INCORPORATED, of 195, Broadway, New York City; New York State, United States of America, a Corporation of the State of New York, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to a coating process for producing a moisture-resistant coating on a metallic or non-metallic surface.

In its preferred embodiment the invention is particularly applicable to electrical devices such as transformers, retard coils and the like. In protecting such a device from the adverse effects of moisture it has generally been customary to place the device within a hermetically sealed metal container filled with a suitable potting compound. However, there are many instances, such as in airborne or portable equipment, where the additional weight of the container and the potting compound and the resulting increase in size are objectionable.

It is an object of the present invention to provide such a device with an adherent moisture-resistant coating which will maintain its characteristics over a wide temperature range.

According to the invention a method of forming a smooth adherent moisture-resistant coating on a surface such as the external surface of an electrical device comprising a formed coil comprises applying to the surface an impregnating coating consisting of a polymerizable resin varnish, drying and baking said coating until the varnish is substantially fully cured, subsequently applying to the surface a final coating of a polymerizable resin varnish containing a suitable amount of a finely divided inert inorganic filler.

[Price

and then drying and baking said final coating for a time and at a temperature sufficient to solidify the resin in said coating but insufficient to produce the complete curing of said resin in said coating.

The invention will be better understood by reference to the following detailed description and the accompanying drawing in which the figure represents one type of electrical device which is provided with a moisture-resistant coating in accordance with the process of the present invention.

The power transformer disclosed in the drawing is of the usual type comprising a closed laminated core 1 with the coil form 2 comprising the primary and secondary windings surrounding one leg of the core and with the coil 2 completely surrounded by a spiral wrapping 3 of an insulating tape of muslin, for example.

The present invention is concerned with the provision of a moisture-resistant coating for such a device, which coating will be substantially moisture-proof even when the device is subjected to water immersion and which will maintain its moisture-resistant properties over a wide temperature range, such as from  $-50^{\circ}\text{C.}$  to  $+125^{\circ}\text{C.}$

The preferred procedure for applying a moisture-resistant coating to a transformer of the type disclosed in the drawing will now be described.

#### IMPREGNATION.

After the transformer has been thoroughly dried by baking in a vacuum for several hours at a temperature of  $230^{\circ}\text{F.}$  the transformer is immediately placed in an unheated tank and maintained under a vacuum while cooling from the baking temperature. An impregnating compound comprising a polymerizable varnish, is then drawn into the tank to cover the transformer completely while still maintaining a vacuum in the tank.

- The vacuum in the tank is maintained for several minutes after which the vacuum is broken and the transformer retained immersed in the impregnating compound for a further period, forty-five minutes for example. The transformer is then removed from the tank, is air dried and drained at room temperature for one hour and is then baked at a temperature of 270° F. for 8 to 10 hours, or until the polymerizable material in the impregnating compound is substantially fully cured. The impregnated transformer is then allowed to cool in the evacuated tank after which the transformer is given a second impregnation with the same impregnating compound in accordance with the same procedure described for the first impregnation including, as a final step, baking at the same temperature and for the same length of time.

#### COATING.

- The doubly impregnated transformer is then given two coatings of a uniform mixture of a coating compound, comprising a polymerizable varnish and finely divided talc (magnesium silicate) in the proportions of 3.5 pounds of talc to 4.1 pounds of the resin content of the varnish.

- The impregnated transformer is first completely immersed in the coating compound for a substantial period and for at least ten minutes after which the transformer is withdrawn, drained and air dried at room temperature for 5 or 6 hours, followed by slowly baking the coated transformer for a period of 5 hours at a temperature of 200° F.  $\pm 10^\circ$  F.

- The coating transformer is again completely immersed in the coating compound for at least ten minutes after which it is withdrawn, drained and air dried at room temperature for 5 or 6 hours, followed by slowly baking the coated transformer for a period of 11 to 12 hours at a temperature of 200° F.  $\pm 10^\circ$  F.

- The period of air drying at substantially room temperature prior to the baking at an elevated temperature is desirable to facilitate the evaporation of the thinner or solvent of the varnish before the coating compound has become hardened. The relatively slow rate of partial curing of each coating is desirable to complete the driving off of the volatile thinner at such a slow rate as to prevent the formation in the coating of voids or holes which if present would result in reduced resistance of the structure to moisture penetration.

- It is preferable that the same varnish be used as the impregnating compound and in the coating compound. One varnish which has been found quite satisfactory for both the impregnating compound and

the coating compound is "Harvell 612C" varnish, manufactured by the Irvington Varnish and Insulator Company. This commercial varnish may be used unchanged in the coating compound but it will generally be found advisable to add a small amount of thinner, such as petroleum naphtha, to the varnish when it is to be used as the impregnating compound. This Harvel varnish comprises the condensation product of formaldehyde and the oil of the cashew nut shell (which contains a phenolic-like component) dissolved in a suitable solvent, such as petroleum naphtha, the varnish having a solid content of 57 per cent.  $\pm 2$  per cent. However, other heat reactive polymerizable varnishes having a low oxidation rate when exposed to air may be employed in the process of this invention.

Purified talc is the preferred finely divided inert inorganic filler to be added to the varnish to form the coating compound. The talc may be either fibrous or amorphous although the amorphous form is preferred. Good results have been obtained when the talc is such that it will pass through a 200 mesh screen, United States standard specification. Talc is particularly advantageous because of its low temperature coefficient of expansion, and because its relatively low density enables it to be uniformly suspended in the varnish. Talc is also desirable because of its good wetting characteristics in varnish and its poor wetting characteristics in water. However, other finely divided inert powders of low temperature coefficient of expansion may be employed in place of talc, such as sand, mica, asbestos, aluminium silicate and chalk.

In order to achieve the best results in making the coated transformer moisture-resistant, it has been found that the amount of talc employed in the coating compound is somewhat critical. It is preferred that the varnish and the talc be mixed in such proportions that the weight of the talc is 85 per cent. of the weight of the solid content of the varnish. However, good results will be obtained if the weight of the talc lies within the range from 80 per cent. to 90 per cent. of the weight of the solid content of the varnish. In any event, the weight of the talc used in the coating compound should be less than the weight of the solid content of the varnish.

The amount of the inert filler employed in the coating compound depends upon the density of the filler. When the following fillers are used in the coating compound in place of talc the weight of each substituted filler in the mixture as compared to the weight of the solid content of the varnish should be as follows:—



	Per cent.
Finely divided sand or silica - - -	85 to 95
Finely divided mica -	90 to 100
5 Finely divided asbestos -	88 to 98
Finely divided aluminium silicate - - -	80 to 90
Finely divided chalk -	88 to 98

It has also been found that the consistency of the varnish-filler coating mixture is somewhat critical in producing the best results. At the time the coating compound is ready for use, its preferred consistency is of 49 seconds  $\pm 4$  seconds when measured in an A.S.T.M. cup with a 0.20 inch hole in accordance with A.S.T.M. method D-333 for testing clear lacquers and lacquer enamels as published in 1942 in Part II of American Society of Testing Materials Standards. Part of the thinner in the varnish may be evaporated or additional thinner added to meet this requirement.

The number of impregnations and the number of coatings to be employed depend somewhat upon the size and configuration of the device to be protected and the temperature range to which the device may be subjected in service. With a small size transformer having over-all dimensions of 4 inches by 4 inches by 4 inches of the configuration shown in the drawing, it has been found that multiple impregnations and multiple coatings are desirable when the requirements are such that the device must maintain its moisture-proofing characteristics over a wide temperature range, such as from  $-55^{\circ}\text{C.}$  to  $+125^{\circ}\text{C.}$  If more than two coatings are found desirable, the final coating should be baked at the temperature and for a time interval the same as specified above in the first coating. For coils larger than the one assumed above, more than two coatings will generally be desirable; even for small size coils more than two coatings may be found advantageous in many instances to obtain increased moisture-resistant characteristics.

An important feature of the baking treatments above described is that while the varnish applied to the device in the two impregnating steps is fully cured, the varnish applied in the two coating steps is only partially cured; that is, the baking temperature and the duration of the baking for each coating are such that the resin content of the coating is only partially polymerized whereby flexible coatings and not hard brittle coatings are produced. With flexible coatings produced in this manner, the device has been found to maintain its moisture-resistant charac-

teristics even when subjected to such wide temperature variations that would cause a fully cured coating to crack.

In order to distinguish more clearly from the partial curing of the varnish-filler coating and the full curing of the varnish impregnations, it may be stated that for each varnish-filler coating the baking is for a time and a temperature such that the coating while solid is still thermoplastic, the resin has not reached the stage of infusibility and the resinous material is still soluble in its original solvent; while for the full curing in the impregnations the varnish is made infusible, is no longer thermoplastic and is insoluble in its original solvent.

After the transformer has had applied thereto two coatings of the varnish-filler mixture a subsequent inspection will disclose no line of demarcation between the first coating and the second coating. The two coatings appear as a single coating and it is impossible to strip off the second coating from the first coating. Since at the time the second coating is applied the resin in the first coating is still in a partially soluble state, it is likely that the surface of the first coating is softened somewhat by the solvent in the second coating to coalesce the two coatings into a unitary coating as the result of the final baking.

It has also been found preferable to achieve the partial curing of the resin in the coating compound at a relatively slow rate; that is, by using a relatively low baking temperature for a considerable length of time rather than by baking at a higher temperature for a shorter time. In particular for the first coating of varnish and talc the preferred baking is at a temperature of  $190^{\circ}\text{F.}$  for a period of 5 hours, although the same amount of partial curing may be obtained at a baking temperature of  $180^{\circ}\text{F.}$  for 8 hours or at a baking temperature of  $210^{\circ}\text{F.}$  for 4 hours. For the final coating of varnish and talc the preferred baking temperature is  $190^{\circ}\text{F.}$  for a period of 12 hours although the same amount of partial curing may be attained at a baking temperature of  $180^{\circ}\text{F.}$  for a period of 15 hours or a baking temperature of  $210^{\circ}\text{F.}$  for a period of 10 hours, and a proportionate number of hours for other temperatures between  $210^{\circ}\text{F.}$  and  $180^{\circ}\text{F.}$

It should also be noted that each coating applied prior to the final coating is baked for a much shorter length of time than the final coating; this is because the baking of the final coating also increases the amount of curing of the earlier coatings and the total baking to which an inner coating is subjected should not be

	Per cent.
Finely divided sand or silica - - -	85 to 95
Finely divided mica -	90 to 100
5 Finely divided asbestos -	88 to 98
Finely divided aluminium silicate - - -	80 to 90
Finely divided chalk -	88 to 98

It has also been found that the consistency of the varnish-filler coating mixture is somewhat critical in producing the best results. At the time the coating compound is ready for use, its preferred consistency is of 49 seconds  $\pm 4$  seconds when measured in an A.S.T.M. cup with a 0.20 inch hole in accordance with A.S.T.M. method D-333 for testing clear lacquers and lacquer enamels as published in 1942 in Part II of American Society of Testing Materials Standards. Part of the thinner in the varnish may be evaporated or additional thinner added to meet this requirement.

The number of impregnations and the number of coatings to be employed depend somewhat upon the size and configuration of the device to be protected and the temperature range to which the device may be subjected in service. With a small size transformer having over-all dimensions of 4 inches by 4 inches by 4 inches of the configuration shown in the drawing, it has been found that multiple impregnations and multiple coatings are desirable when the requirements are such that the device must maintain its moisture-proofing characteristics over a wide temperature range, such as from  $-55^{\circ}\text{C}$ . to  $+125^{\circ}\text{C}$ . If more than two coatings are found desirable, the final coating should be baked at the temperature and for a time interval the same as specified above in the first coating. For coils larger than the one assumed above, more than two coatings will generally be desirable; even for small size coils more than two coatings may be found advantageous in many instances to obtain increased moisture-resistant characteristics.

An important feature of the baking treatments above described is that while the varnish applied to the device in the two impregnating steps is fully cured, the varnish applied in the two coating steps is only partially cured; that is, the baking temperature and the duration of the baking for each coating are such that the resin content of the coating is only partially polymerized whereby flexible coatings and not hard brittle coatings are produced. With flexible coatings produced in this manner, the device has been found to maintain its moisture-resistant charac-

teristics even when subjected to such wide temperature variations that would cause a fully cured coating to crack.

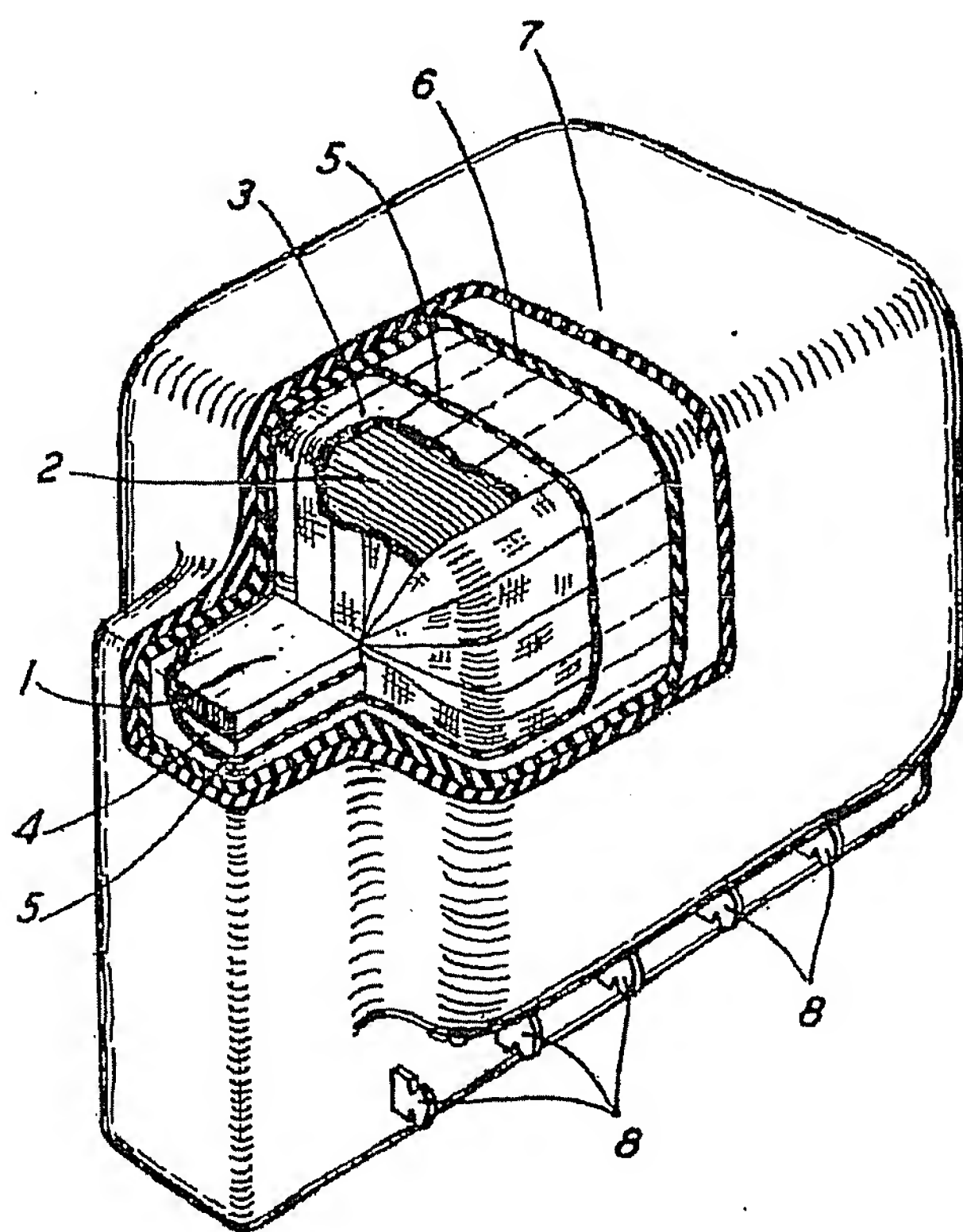
In order to distinguish more clearly from the partial curing of the varnish-filler coating and the full curing of the varnish impregnations, it may be stated that for each varnish-filler coating the baking is for a time and a temperature such that the coating while solid is still thermoplastic, the resin has not reached the stage of infusibility and the resinous material is still soluble in its original solvent; while for the full curing in the impregnations the varnish is made infusible, is no longer thermoplastic and is insoluble in its original solvent.

After the transformer has had applied thereto two coatings of the varnish-filler mixture a subsequent inspection will disclose no line of demarcation between the first coating and the second coating. The two coatings appear as a single coating and it is impossible to strip off the second coating from the first coating. Since at the time the second coating is applied the resin in the first coating is still in a partially soluble state, it is likely that the surface of the first coating is softened somewhat by the solvent in the second coating to coalesce the two coatings into a unitary coating as the result of the final baking.

It has also been found preferable to achieve the partial curing of the resin in the coating compound at a relatively slow rate, that is, by using a relatively low baking temperature for a considerable length of time rather than by baking at a higher temperature for a shorter time. In particular for the first coating of varnish and talc the preferred baking is at a temperature of  $190^{\circ}\text{F}$ . for a period of 5 hours, although the same amount of partial curing may be obtained at a baking temperature of  $180^{\circ}\text{F}$ . for 8 hours or at a baking temperature of  $210^{\circ}\text{F}$ . for 4 hours. For the final coating of varnish and talc the preferred baking temperature is  $190^{\circ}\text{F}$ . for a period of 12 hours although the same amount of partial curing may be attained at a baking temperature of  $180^{\circ}\text{F}$ . for a period of 15 hours or a baking temperature of  $210^{\circ}\text{F}$ . for a period of 10 hours, and a proportionate number of hours for other temperatures between  $210^{\circ}\text{F}$ . and  $180^{\circ}\text{F}$ .

It should also be noted that each coating applied prior to the final coating is baked for a much shorter length of time than the final coating; this is because the baking of the final coating also increases the amount of curing of the earlier coatings and the total baking to which an inner coating is subjected should not be

[This Drawing is a reproduction of the Original on a reduced scale.]



H.M.S.O. (Ty. P.)